

Effects of pollution on the morphology and condition of *Littorina littorea* along the Scheldt estuary

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Introduction

The Scheldt estuary (The Netherlands) consists of 2 tributaries, of which the western part is heavily polluted and the eastern is relatively clean. The Western Scheldt estuary has been ranked among the most heavily polluted in the world with reference to metal concentrations. A metal pollution gradient, which increases upstream, has been reported in the sentinel species *Littorina littorea*^[1]. Furthermore, effects of tributyltin (TBT) pollution, namely intersex (i.e. masculinized phenotype) in *Littorina littorea*, have been detected in the Western Scheldt estuary^[2,3]. Besides these anthropogenic stress gradients (i.e. metal and TBT pollution), the Western Scheldt estuary is also subjected to natural stressors (i.e. salinity, O₂, organic material).

??? Question ???

Can we detect differences in shell morphology, reproductive anatomy and condition that are stress related, in the Scheldt estuary using the periwinkle *Littorina littorea*?



Figure 1. Overview of the Scheldt estuary and the different sampling sites of *Littorina littorea*. W1 Hanswoert, W2 Hoedekenskerke, W3 Ellewoutsdijk, W4 Borsselo, W5 Vlissingen, W6 Westkapelle, E1 Krabbendijke, E2 Yerseke, E3 Wemeldinge, E4 Kattendijke.

Materials & Methods

- *L. littorea* sampling: 6 sites along the **Western Scheldt**, 4 sites along the **Eastern Scheldt** (n = 395) (Figure 1).
- Shell morphology: shell height, shell width, aperture height, aperture width, top height, total weight and body weight were measured.
- Reproductive anatomy: sex was based on presence/absence of vesicula seminalis.
 - Males: checked for penis shedding.
 - Females: assessment of intersex and sterility.
- Condition: 1) Lipid concentration was determined using the method of Bligh and Dyer^[4] 2) Dry:wet weight ratio was assessed.

Results & Discussion

Within **Western Scheldt**

- Significant differences for shell morphology (Figure 2).
- Significant differences for the distribution of intersex (i.e. ISI index) and sterility in females. Site W4 has the highest ISI index and sterility (Figure 3), which is probably caused by its close proximity to the harbour of Vlissingen.
- Significant differences for condition (i.e. lipid concentration and dry:wet weight ratio). Both parameters increased downstream (Figure 4), thus opposing the known metal pollution gradient.

Within **Eastern Scheldt**

- Significant differences only for shell morphology (Figure 2).

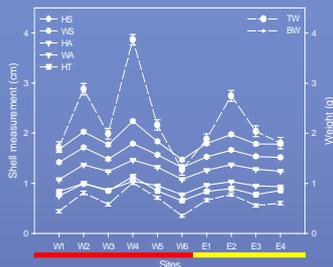


Figure 2. Mean shell height (HS), shell width (WS), aperture height (HA), aperture width (WA), shell top height (HT), total weight (TW), body weight (BW) and standard errors for *Littorina littorea* collected along the entire Scheldt estuary.

Between **Western** and **Eastern Scheldt**

- Significant differences for shell morphology (Figure 2).
- Significant differences for the distribution of intersex (i.e. ISI index) and sterility in females. The **Western Scheldt** has a higher ISI index and sterility percentage than the **Eastern Scheldt** (Figure 3).
- Canonical Discriminant Analysis (CDA): the main difference between **Western** and **Eastern Scheldt** is caused by the vectors total weight and body weight which are oppositely orientated (Figure 5).

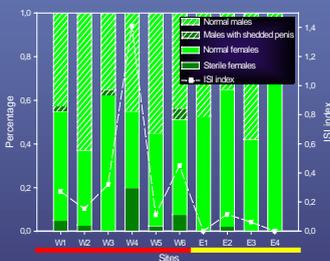


Figure 3. Distribution of female (normal and sterile) and male (normal and penis shedded) *Littorina littorea* along the entire Scheldt estuary. Intersex index (ISI) of females is also given.

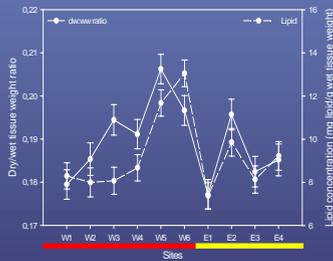


Figure 4. Mean dry:wet weight ratio (dw:ww), lipid concentration and standard errors for *Littorina littorea* collected along the Scheldt estuary.

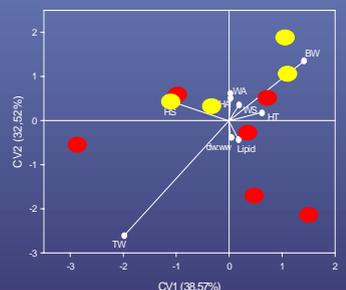


Figure 5. Graphical representation of the first two canonical variables, representing all sampling sites collected along the Scheldt estuary.

Conclusions

Intersex and sterility, which are known indicators for TBT pollution, show a difference in distribution between the **Western** and **Eastern Scheldt** estuary

The pattern of the condition parameters opposes that of the known pollution gradient

References

- [1] De Wolf et al. (2005) *Marine Pollution Bulletin* 50: 479-484.
- [2] De Wolf et al. (2001) *Marine Environmental Research* 52: 249-255.
- [3] De Wolf et al. (2004) *Marine Pollution Bulletin* 48: 592-596.
- [4] Bligh & Dyer (1959) *Canadian Journal of Biochemistry and Physiology* 37: 911-917.